April 2, 1968 J. H. KETTERING ET AL 3,376,080

EMPTY AND LOAD BRAKE CONTROL APPARATUS FOR RAILWAY CARS

Filed Sept. 30, 1966 2 Sheets-Sheet 1

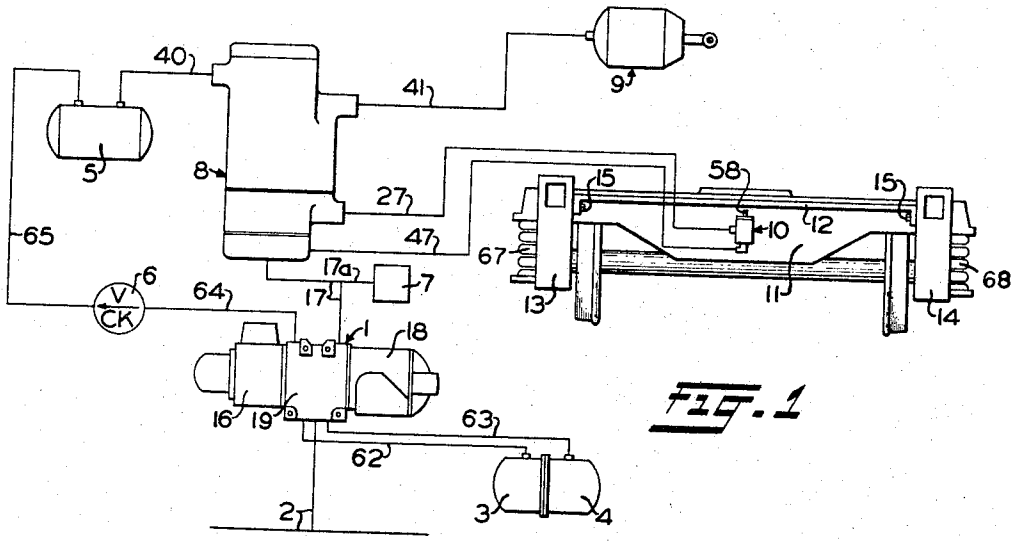


FIG. 1

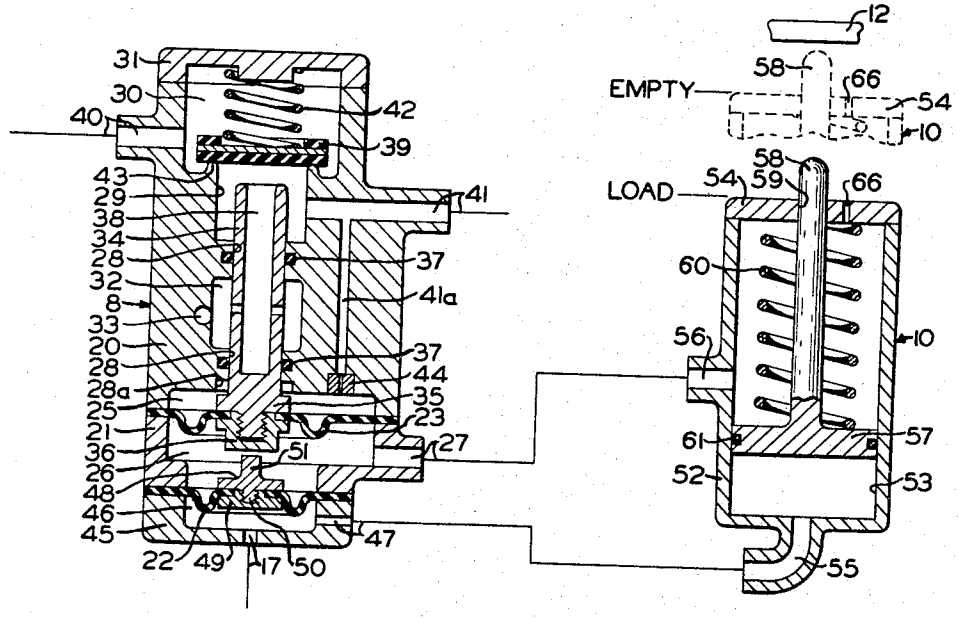


FIG. 2

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2 Sheets-Sheet 2

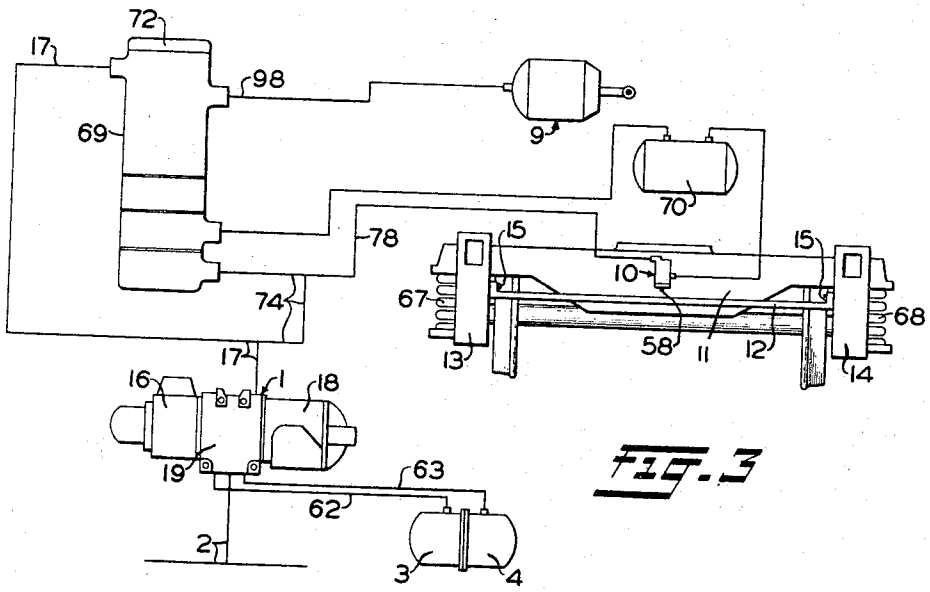


FIG. 3

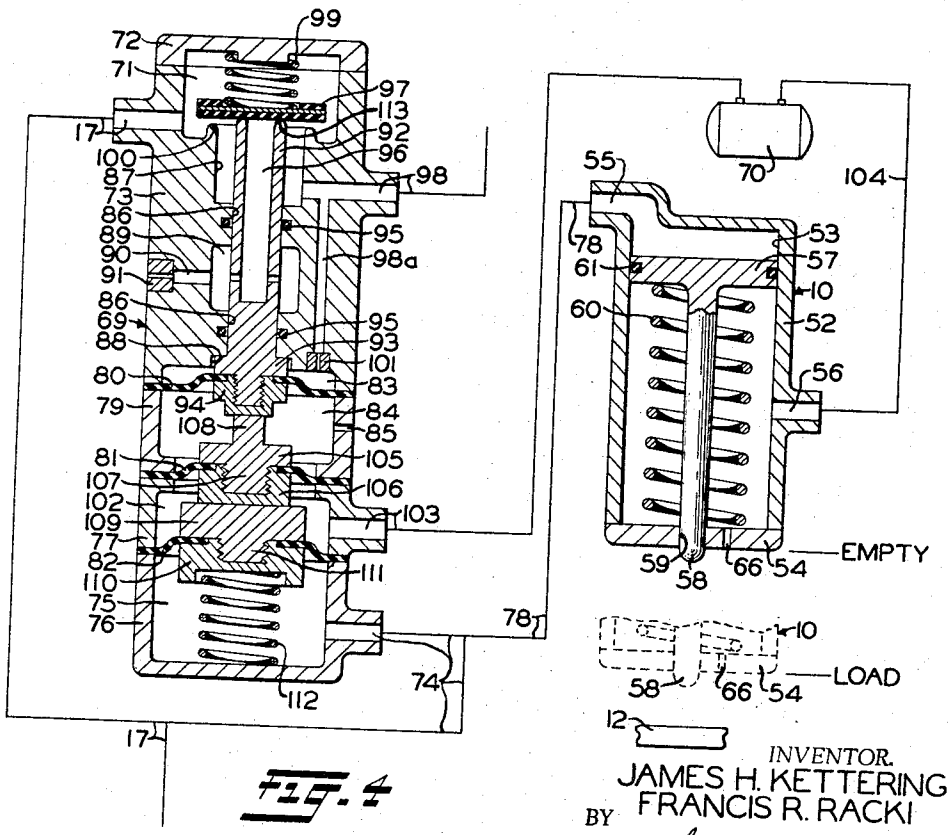


FIG. 4

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United States Patent Office 3,376,080 Patented Apr. 2, 1968

3,376,080

EMPTY AND LOAD BRAKE CONTROL APPARATUS FOR RAILWAY CARS

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Filed Sept. 30, 1966, Ser. No. 583,335
5 Claims. (Cl. 303—22)

ABSTRACT OF THE DISCLOSURE

An empty and load brake control apparatus for railway cars in which a load measuring operation is automaticaly effected each time a brake application is made to thereby cause a change in the degree of the application effected subsequent to each change in the load carried by the car.

BACKGROUND OF THE INVENTION

The empty and load brake control apparatus heretofore known for railway vehicles has usually comprised a brake control change-over valve device carried by the body of the vehicle and a load-measuring or strut cylinder device which is installed on the end of a truck bolster and connected by flexible conduits to the change-over valve device since the truck bolster constitutes a part of the vehicle truck and therefore, turns relative to the vehicle body as the vehicle travels around a curve. The initial cost of such empty and load brake control apparatus is relatively high and the maintenance cost, including that of the conduits connecting the change-over valve device and the strut cylinder device, is often prohibitive.

Furthermore, most of the heretofore known empty and load brake control apparatus for railway vehicles is automatically conditioned or changed over to provide either empty or load braking accordingly as the vehicle is empty or loaded only while the train brake pipe pressure is increasing during charging subsequent to a reduction in the pressure in the train brake pipe to substantially zero, a condition not obtained when a full or partial service application is effected but only when an emergency application is effected.

Accordingly, it is the general purpose of this invention to provide a simple and inexpensive empty and load brake apparatus in which the functions of a change-over valve device and of a load-measuring strut cylinder device are performed by a differential type of fluid pressure operated relay valve device and a load-measuring strut cylinder device each carried on a sprung part of a railway vehicle which relay valve device is conditioned to provide indirectly a pressure in a brake cylinder device in accordance with the load carried on the body.

More specifically, the invention comprises a simple and inexpensive fluid motor or load-measuring strut cylinder device that may be installed on any suitable sprung part of the vehicle such as, for example, a truck bolster substantially midway the length thereof and connected by either piping or flexible hose to a relay valve device which, in turn, is connected by piping to a conventional AB fluid pressure brake control equipment. This strut cylinder device is operated each time a brake application is effected to move a strut piston and piston rod into contact with a stop, the distance moved by the piston and piston rod varying in accordance with the load on a railway car. This distance traveled by the piston and piston rod determines whether or not fluid under pressure is supplied to one side of one diaphragm of a diaphragm stack of a differential type relay valve device or to both sides of the one and also to one side of another diaphragm of the stack to thereby effect operation of the relay valve device to a condition which, when fluid under pressure is supplied under the control of the usual AB control valve device, controls the fluid under pressure supplied to the brake cylinder device in accordance with the empty or loaded condition of the car.

The above-mentioned differential type relay valve device and strut cylinder device constituting the present invention can be added to a railway freight car presently provided with a standard single capacity brake equipment, such as the well-known AB freight brake equipment, to convert the brake equipment on the car to a double capacity empty and load freight brake equipment without adding any additional brake rigging. Moreover, it can be used to replace the more costly and complicated change-over valve device and the corresponding strut cylinder device which, together with either an empty brake cylinder device and a load brake cylinder device, or a compensating type of brake cylinder device and a control valve device, such as the well-known AB control valve device, constitute the principal elements of some of the empty and load freight brake equipments presently installed on a large number of freight cars in service on American railroads. By effecting such replacement, these cars may be provided with an upgraded empty and load brake equipment which is more simple in operation and less costly to maintain without the necessity of effecting any changes in or additions to the brake rigging presently on the freight car.

In the accompanying drawings:

FIG. 1 is a diagrammatic view, in outline, showing an empty and load railway freight car brake equipment constructed in accordance with one embodiment of the invention.

FIG. 2 is a vertical cross-sectional view, at an enlarged scale, of the novel differential type relay valve device and strut cylinder device of FIG. 1 showing the structural details of these devices.

FIG. 3 is a diagrammatic view, in outline, showing an empty and load railway freight car brake equipment constructed in accordance with a second embodiment of the invention.

FIG. 4 is a vertical cross-sectional view, at an enlarged scale, of a differential type relay valve device and a strut cylinder device of FIG. 3 showing the structural details of these valve devices.

DESCRIPTION, FIGS. 1 AND 2

In FIG. 1 of the drawing, there is shown an empty and load fluid pressure brake equipment constructed in accordance with one embodiment of the invention. This empty and load fluid pressure brake equipment comprises a brake control valve device **1** to which is connected the usual brake pipe **2**, auxiliary reservoir **3**, and emergency reservoir **4**. The empty and load brake equipment shown in FIG. 1 further includes an additional supply reservoir **5** that is charged from the brake pipe **2** via the brake control valve device **1** and a one-way check valve device **6**, a displacement volume reservoir **7**, a double diaphragm differential type self-lapping relay valve device **8**, a brake cylinder device **9** and a fluid motor or strut cylinder device **10** that is mounted by any suitable means (not shown) substantially midway the length of a truck bolster **11** that constitutes a sprung part of a freight car. It will be understood that the other above-mentioned parts of the brake equipment, as well as the strut cylinder device **10**, are also mounted on a suitable sprung part of the freight car. The truck bolster **11** and strut cylinder device **10** carried thereby are movable vertically relative to a stop **12** carried on an unsprung part of a railway car. This stop **12** may be such as, for example, a rod rectangular in cross section and extending between the two side frames **13** and **14** of the car truck so as to have an angle bracket

formed at each end thereof connected to a corresponding side frame by a cap screw **15**.

The brake control valve device **1** shown in FIG. 1 of the drawings is of the AB type which may be of substantially the same operating characteristics as the brake control valve device fully described in Patent 2,031,213, issued Feb. 18, 1936 to Clyde C. Farmer and assigned to the assignee of the present invention, in view of which it is deemed unnecessary to show and describe this valve device in detail.

Briefly, however, the brake control valve device **1** comprises a service portion **16** adapted to operate upon both a service and an emergency rate of reduction in pressure of fluid in brake pipe **2** for supplying fluid under pressure from the auxiliary reservoir **3** to a brake cylinder pipe **17** and to the relay valve device **8** connected thereto. The relay valve device **8** is operated by the fluid under pressure thus supplied thereto, upon a service reduction in brake pipe pressure, to effect the supply of fluid under pressure from the supply reservoir **5** to the brake cylinder device **9**, in a manner hereinafter described in detail, for effecting a service application of the brakes on the vehicle. The brake control valve device **1** also comprises an emergency portion **18** which is adapted to operate only upon an emergency rate of reduction in pressure of fluid in brake pipe **2** for supplying fluid under pressure from the emergency reservoir **4** to the pipe **17**. This fluid under pressure thus supplied from the emergency reservoir **4** to the pipe **17**, in addition to that provided in this pipe from auxiliary reservoir **3** by operation of the service portion **16**, is adapted to operate the relay valve device **8** to provide a higher pressure in the brake cylinder device **9** to cause an emergency application of the brakes on the vehicle. Upon recharging the brake pipe **2**, the brake control valve device **1** is adapted to operate to open the pipe **17** to atmosphere for releasing fluid under pressure therefrom to cause the relay valve device **8** to operate to release fluid under pressure from the brake cylinder device **9** thereby releasing the brakes on the vehicle and at the same time to effect the recharging of the auxiliary reservoir **3** and emergency reservoir **4** in the usual well-known manner. The service and emergency portions **16** and **18**, respectively, of the brake control valve device **1** are mounted on opposite faces of a pipe bracket **19** to which all pipe connections to the valve device **1** are made, as shown in FIG. 1 of the drawings.

Briefly, the double diaphragm self-lapping relay valve device **8** comprises, as shown in FIG. 2 of the drawings, sectionalized casing embodying two casing sections **20** and **21** and two coaxially arranged movable abutments or diaphragms **22** and **23** of different effective areas. The outer periphery of the larger diaphragm **23** is clamped between the casing sections **20** and **21** which are secured together by any suitable means (not shown).

The diaphragm **23** cooperates with the casing sections **20** and **21** and the diaphragm **22** to form within the relay valve device **8** and on opposite sides of the diaphragm **23**, a first pair of chambers **25** and **26**, the latter being connected by a passageway and corresponding pipe **27** to the strut cylinder device **10**.

The casing section **20** of the above-mentioned sectionalized casing of the relay valve device **8** is provided with a bore **28** that at its upper end opens into a coaxial counterbore **29** that in turn opens into a chamber **30** formed by the cooperative relationship between the upper end of the casing section **20** and a cover member **31** secured to the casing section **20** by any suitable means (not shown). The opposite or lower end of the bore **28** opens into a second coaxial counterbore **28***a* that in turn opens into the chamebr **25**. The casing section **20** is provided intermediate the ends of the bore **28** with an annular chamber **32** which is open to atmosphere via a passageway and port **33**. Slidably mounted in the bore **28** is a valve stem **34** having intermediate its ends a collar **35** below which is a screw-threaded portion of reduced diameter which extends through the diaphragm **23** and receives in screw-threaded engagement therewith a combined diaphragm follower plate and nut **36** whereby the diaphragm **23** is operatively connected to the valve stem **34**.

The wall of the bore **28** in the casing section **20** is provided with two identical spaced-apart peripheral annular grooves in each of which is disposed an O-ring **37** in sealing surrounding relation to the valve stem **34** to prevent leakage of fluid under pressure between the periphery of the valve stem and the wall of the bore **28**, and from the chamber **25** and counterbore **29** to the atmospheric chamber **32**.

The valve stem **34** is provided with a crossbore which, as shown in FIG. 2 illustrating the relative positions of the parts of the double diaphragm self-lapping relay valve device **8** in the brake release position, is so located that the interior of the counterbore **29** is open to atmosphere via a passageway **38** extending from the upper end of the valve stem **34** longitudinally therethrough to below the location thereon of the crossbore, the chamber **32** and the passageway and corresponding port **33**.

A flat disc valve **39** is disposed in the chamber **30** which is supplied with fluid under pressure from the supply reservoir **5** via a passageway and corresponding pipe **40** connected to the reservoir **5**. The valve **39** controls communication between the chamber **30** and the interior of the counterbore **29** at the wall surface of which opens one end of a passageway **41** that extends through the casing section **20** and is connected by a pipe bearing the same numeral to the brake cylinder device **9**.

A spring **42**, interposed between the valve **39** and the cover member **31**, urges the valve **39** downward for normally seating it against an annular valve seat **43** formed at the upper end of the counterbore **29**.

The above-mentioned passageway **41** has a branch passageway **41***a* opening into the chamber **25** via a choke **44** which controls the rate of flow of fluid under pressure to and from the chamber **25**.

The outer periphery of the smaller diaphragm **22** is clamped between the casing section **21** and a bottom cover member **45** which is secured to the casing section **21** by any suitable means (not shown) and which cooperates with the diaphragm **22** to form a chamber **46** into which opens the brake cylinder passageway and corresponding pipe **17** which is connected by a branch pipe **17***a* (FIG 1) to the herinbefore-mentioned displacement reservoir **7**. Also opening into the chamber **46** is one end of a passageway **47** which is connected by a pipe bearing the same numeral to the strut cylinder device **10** which will be hereinafter described in detail. The inner periphery of the smaller diaphragm **22** is clamped between a diaphragm follower **48** and a nut **49** that has screw-threaded engagement with a screw-threaded stem **50** integral with the follower **48** and extending from one side thereof through the diaphragm **22**. The opposite side of the diaphragm **48** is provided with a non-screw-threaded stem **51** which is coaxial with the hereinbefore-mentioned valve stem **34**.

The strut cylinder device **10**, as shown in cross section in FIG 2, comprises a body **52** in which is provided a bottom bore **53** the open end of which is closed by a cover member **54** that is secured to the body **52** by any suitable means (not shown). Opening into the lower end of the bottom bore **53** is a passageway **55** to which one end of the hereinbefore-mentioned pipe **47** is connected, and opening at the wall surface of this bottom bore **53** intermediate the ends thereof is a second passageway **56** to which one end of the hereinbefore-mentioned pipe **27** is connected.

A strut piston **57** slidably disposed in the bottom bore **53** and having a piston rod **58** extending through a bore **59** in the cover member **54** is normally biased in the direction of the lower end of the bottom bore **53** by a spring **60** disposed in surrounding relation to the piston

rod 58 and interposed between the upper face of the strut piston 57 and the cover member 54. The piston 57 is provided with a peripheral annular groove in which is disposed an O-ring 61 which, until the strut piston 57 is moved upward a chosen distance against the yielding resistance of the spring 60, prevents the flow of fluid under pressure from the lower face of the piston 57 to the passageway 56 and pipe 27.

OPERATION, FIGS. 1 AND 2

Initial charging

In initially charging the empty and load brake equipment shown in FIG 1 of the drawings, fluid under pressure supplied to the brake pipe 2 by the brake valve device (not shown) on the locomotive flows to the brake control valve device 1 and thence through this device and pipes 62 and 63 to the auxiliary and emergency reservoirs 3 and 4, respectively, to effect charging of these reservoirs in the usual well-known manner. Furthermore, fluid under pressure flows from the brake pipe 2 through the brake control valve device 1, a pipe 64, the check valve device 6 and a pipe 65 to the supply reservoir 5 to effect the charging of this reservoir.

It will be understood that at this time the brake cylinder device 9 and the various chambers in the relay valve device 8 and strut cylinder device 10 are devoid of fluid under pressure.

Service application of the brakes on an empty vehicle

When it is desired to effect a service application of the brakes, the fluid pressure in the brake pipe 2 will be reduced in the usual manner by operation of the brake valve on the locomotive to cause the brake control valve device 1 to effect the supply of fluid under pressure from the auxiliary reservoir 3 to the brake cylinder pipe 17 which is connected by the corresponding passageway to the chamber 46 in the relay valve device 8, and by the branch pipe 17*a* to the displacement reservoir 7. By thus connecting the displacement reservoir 7 to the chamber 46, when a brake application is effected, the same equalization pressure between the auxiliary reservoir 3, the chamber 46 and the displacement reservoir 7 is obtained as is obtained by equalization of the auxiliary reservoir pressure into the brake cylinder device in conventional single capacity brake equipment using the well-known AB control valve device.

Fluid under pressure supplied to the chamber 46 in the manner described above will flow therefrom to the lower end of the bottom bore 53 and the lower face of the strut piston 57 via passageway and corresponding pipe 47 and the passageway 55.

Fluid under pressure supplied to the lower face of the piston 57 in the manner just described is effective to move this piston and the piston rod 58 upward against the yielding resistance of the spring 60.

Assuming that the vehicle is empty, the strut cylinder device 10 will occupy, with respect to the stop 12, the position indicated by broken lines in FIG. 2. Therefore, the strut piston 57 and piston rod 58 will thus be moved upward until the upper end of the piston rod is moved into contact with the stop 12 carried by the truck side frames 13 and 14.

When the piston 57 is moved upward to the position in which the upper end of the piston rod 58 is in contact with the stop 12, the O-ring 61 carried by the piston 57 is in a position in which it forms a seal with the wall surface of the bottom bore 53 just below the opening of the passageway 56 at the wall surface of this bottom bore 53. Therefore, the fluid under pressure supplied from the brake cylinder pipe 17 to the lower face of the piston 57 via the pathway previously described cannot flow to the chamber 26 above the diaphragm 22 via the passageway 56 and the pipe and corresponding passageway 27. Consequently, the chamber 26 remains open to atmosphere via the passageway and corresponding pipe 27, passageway 56, that portion of the bottom bore 53 above the strut piston 57 and a port 66 provided in the cover member 54.

As the fluid under pressure supplied to the chamber 46 in the manner previously described increases the pressure in this chamber, the diaphragm 22 is deflected upward until the stem 51 is moved into contact with the combined diaphragm follower plate and nut 36 after which the diaghragms 22 and 23 are simultaneously deflected upward to first move the upper end of the valve stem 34 into contact with the lower side of the valve 39 to close communication between the pressure chamber (not shown) in the brake cylinder device 9 and atmosphere. As the diaphragms 22 and 23 continue to be deflected upward, subsequent to movement of the upper end of the valve stem 34 into contact with the lower side of the valve 39, this valve 39 will be moved upward away from the valve seat 43 against the yielding resistance of the spring 42.

Upon the unseating of valve 39 from the valve seat 43, fluid under pressure will flow from the supply reservoir 5 to the pressure chamber in the brake cylinder device 9 shown in FIG. 1 via pipe and passageway 40, chamber 30 (FIG. 2), past unseated valve 39, counterbore 29 and passageway and corresponding pipe 41. Consequently, the brake cylinder device 9 (FIG. 1) is effective in response to the supply of fluid under pressure to the pressure chamber thereof to effect a brake application on the vehicle.

Some of the fluid under pressure supplied to the passageway 41 (FIG. 2) in the manner described above flows to the chamber 25 above the larger diaphragm 23 via the branch passageway 41*a* and the choke 44. The fluid under pressure thus supplied to the chamber 25 acts on the effective area of the larger diaphragm 23 in a direction opposite to the direction that the fluid under pressure supplied to the chamber 46 acts on the effective area of the smaller diaphragm 22 so that when these oppositely acting fluid pressure forces are substantially balanced, the spring 42 will be rendered effective to move the valve 39, stem 34 and diaphragms 23 and 22 downward to seat valve 39 on the valve seat 43 to cut off flow of fluid under pressure from the supply reservoir 5 to the pressure chamber in the brake cylinder device 9. From the foregoing, it is apparent that, since the effective area of the diaphragm 23 is greater than the effective area of the diaphragm 22, the pressure supplied to the pressure chamber of the brake cylinder device 9 and to the chamber 25 is less than the pressure supplied to the chamber 46 and in inverse ratio to that of the effective areas of the larger diaphragm 23 and the smaller diaphragm 22. It will be understood, however, that this pressure in the pressure chamber of the brake cylinder device 9 provides an adequate braking force for an empty vehicle.

Release of a service application on an empty vehicle

When it is desired to effect a release of a service brake application, the pressure in the brake pipe 2 will be increased in the usual manner to cause the service slide valve (not shown) of the service portion 16 of the brake control valve device 1 to be returned to its release position so that a communication is established therethrough from the brake cylinder pipe 17 to atmosphere.

Since the brake cylinder pipe 17 is now open to atmosphere and this pipe is connected by the corresponding passageway to the chamber 46 in the relay valve device 8, and by the branch pipe 17*a* to the displacement volume reservoir 7, the fluid under pressure in the chamber 46, the reservoir 7, and also in the bottom bore 53 below the piston 57 which is connected to the chamber 46 via passageway 55 and passageway and pipe 47, will be vented to atmosphere.

As fluid under pressure is vented from the chamber 46, as just described, the fluid under pressure in the chamber 25 is rendered effective to deflect the diaphragms 22 and 23 downward and thereby move the valve stem 34 downward to the position shown in FIG. 2, whereupon the

pressure chamber in the brake cylinder device **9** is open to atmosphere via pipe and passageway **41**, counterbore **29**, passageway **38** and the crossbore in the stem **34**, chamber **32**, and passageway and port **33** to release the fluid under pressure therefrom thereby releasing the brakes on the vehicle.

Service application of the brake on a loaded vehicle

Let it be supposed that the brake equipment shown in FIG. 1 has been charged in the manner hereinbefore described and that the vehicle is fully loaded.

When the vehicle is fully loaded, one half of the load is transmitted from the vehicle body to the bolster **11** of the truck at one end of the vehicle and the other half of the load is transmitted from the vehicle body to the bolster of the truck at the other end of the vehicle. The load transmitted to the bolster **11** shown in FIG. 1 is effective to compress the truck springs **67** and **68** interposed between the respective end of the truck bolster and the corresponding truck spring plank (not shown) of the respective side frame **13** and **14** so that the bolster **11** and the strut cylinder device **10** carried thereon are moved downward from the position they occupied when the vehicle was empty toward the truck spring planks a distance proportional to the load on the bolster. Consequently, the distance between the upper end of the piston rod **58** and the bottom surface of the stop **12** will increase until the strut cylinder device **10** and the upper end of the piston rod **58** thereof occupy, with respect to the stop **12**, the position in which they are shown in full lines in FIG. 2 of the drawings. Therefore, when a service brake application is effected in the manner hereinbefore described and fluid under pressure is supplied to the brake cylinder pipe **17** and chamber **46** and thence to the lower face of the strut piston **57**, via passageway and pipe **47**, passageway **55** and the lower portion of the bottom bore **53**, this piston **57** will move upward against the yielding resistance of spring **60** until it is brought to a stop by the upper end of the piston rod **58** contacting the bottom of the stop **12**. In this position of the piston **57**, the O-ring **61** carried thereon is disposed above the opening of the passageway **56** at the wall surface of the bottom bore **53**. Consequently, the fluid under pressure supplied to the lower face of the piston **57** in the manner described above will flow to the chamber **26** above the smaller diaphragm **22** in the relay valve device **8** via the passageway **56** and pipe and corresponding passageway **27**.

The simultaneous supply of fluid under pressure to the chambers **46** and **26** acts on the opposite sides of the effective area of the smaller diaphragm **22** to balance the opposing fluid pressure forces acting on this diaphragm and thereby render it ineffective.

The fluid under pressure supplied to the chamber **26** acts in an upward direction on the entire effective area of the larger diaphragm **23** to deflect this diaphragm in the direction to first move the valve stem **34** upward to the position in which the upper end thereof abuts the lower face of the valve **39** to close communication between the pressure chamber in the brake cylinder device **9** and atmosphere, and thereafter effect unseating of the valve **39** from the valve seat **43** whereupon fluid under pressure flows from the supply reservoir **5** to the pressure chamber in the brake cylinder device **9** to effect a service brake application.

Fluid under pressure supplied to the brake cylinder device **9** also flows to the chamber **25** above the larger diaphragm **23** via branch passageway **41***a* and choke **44** where it acts in a downward direction over the effective area of this diaphragm. Consequently, when the pressure in the chamber **25** is increased to substantially the same value as that in the chamber **26**, the opposing fluid pressure forces acting on the diaphragm **23** will be balanced whereupon the spring **42** will effect reseating of the valve **39** on its seat **43** to cut off further supply of fluid under pressure to the pressure chamber in the brake cylinder device **9** and the chamber **25**.

Since fluid under pressure is supplied to the chamber **25** until it substantially equals the pressure in the chamber **26**, it is apparent that this pressure, which is the same as that in the pressure chamber of the brake cylinder device **9**, provides for a greater braking force on the loaded vehicle than is provided for an empty vehicle.

Release of a service application of brakes on a loaded vehicle

To release a service brake application on a loaded vehicle, the pressure in the brake pipe **2** is increased to its normal charged value to cause the brake control valve device **1** to operate to establish a communication between the brake cylinder pipe **17** and atmosphere.

The chamber **26** in the double diaphragm differential type relay valve device **8** is connected to the chamber **46** in this relay valve device via passageway and corresponding pipe **27**, passageway **56**, bottom bore **53** in strut cylinder device **10**, passageway **55** and pipe and corresponding passageway **47**, and the brake cylinder pipe **17** is connected by the corresponding passageway to the chamber **46**. Consequently, fluid under pressure will now be vented from the chambers **26** and **46** to atmosphere.

As fluid under pressure is vented from the chambers **26** and **46** in the relay valve device **8**, the fluid under pressure present in the chamber **25** in this valve device is rendered effective to deflect the diaphragm **23** downward to move the valve stem **34** to the position shown in FIG. 2 whereupon fluid under pressure is vented from the brake cylinder device **9** to atmosphere in the manner hereinbefore described in detail to cause a release of the brakes.

Emergency application and release of brakes

An emergency brake application on both an empty and a loaded vehicle differs from a service brake application only in that when an emergency brake application is effected, fluid under pressure is supplied from both the auxiliary reservoir **3** and the emergency reservoir **4** to, when the vehicle is empty, only the chamber **46** in the relay valve device **8**, and, when the vehicle is loaded, to both the chamber **46** and the chamber **26** in this valve device. By supplying fluid under pressure from both the auxiliary reservoir **3** and the emergency reservoir **4**, a higher equalization pressure is obtained and, therefore, a higher braking force is transmitted by the brake cylinder device **9** to the brake shoes (not shown) for pressing the brake shoes against the tread surface of the vehicle wheels.

The release of an emergency brake application on either an empty or a loaded vehicle is identical to the release of a service brake application.

DESCRIPTION, FIGS. 3 AND 4

In FIG. 3 of the drawings, there is shown an empty and load fluid pressure brake equipment constructed in accordance with a second embodiment of the invention. According to this second embodiment of the invention, the empty and load fluid pressure brake equipment shown in FIG. 3 differs from the empty and load fluid pressure brake equipment shown in FIG. 1 only in that the strut cylinder device is mounted in an inverted position, the supply reservoir **5** and check valve device **6** are omitted and the double diaphragm differential type relay valve device **8** is replaced by a triple diaphragm differential type self-lapping relay valve device **69**. Accordingly, like reference numerals have been used to designate the structure shown in FIG. 3 which is identical to that shown in FIG. 1. Only such features of the structure and operation of the embodiment of the invention shown in FIG. 3 which differ from that of the embodiment of FIG. 1 will be hereinafter described.

According to the embodiment of the invention disclosed in FIG. 3, the empty and load fluid pressure brake equip-

ment shown in this figure comprises the brake control valve device 1 to which is connected the usual brake pipe 2, auxiliary reservoir 3, emergency reservoir 4 and the above-mentioned relay valve device 69. This relay valve device 69 is in turn connected to the brake cylinder device 9 and to the strut cylinder device 10 which device 10 is mounted in an inverted position substantially midway the truck bolster 11. Strut cylinder device 10 is movable vertically relative to the stop 12 that is secured to and carried on an unsprung part of a railway vehicle truck, such as, for example, the truck side frames 13 and 14 it being noted that the stop 12 shown in FIG. 3 is disposed somewhat below the position of stop 12 shown in FIG. 1. The relay valve device 69 is also connected to a displacement volume reservoir 70 that in turn is connected to the strut cylinder device 10 in a manner hereinafter described in detail.

One end of the brake cylinder pipe 17 is connected to the brake cylinder passageway in the pipe bracket 19 of the brake control valve device 1, as in the first embodiment of the invention shown in FIG. 1 of the drawings, and the opposite end of the brake cylinder pipe 17 is connected by a passageway bearing the same numeral to a supply chamber 71 (FIG. 4) formed in the relay valve device 69 by the cooperative relationship of a cover member 72 and a first casing section 73 of a sectionalized casing of the relay valve device 69, the cover member 72 being secured to the casing section 73 by any suitable means (not shown). Connected to the brake cylinder pipe 17 intermediate the ends thereof is one end of a pipe 74 that has its opposite end connected to a passageway bearing the same numeral which passageway opens into a chamber 75 formed in the relay valve device 69 by the cooperative relationship of a bottom cover member 76 and a second casing section 77 of the sectionalized casing of the relay valve device 69, the bottom cover member 76 being secured to the second casing section 77 by any suitable means (not shown).

Connected to the above-mentioned pipe 74 intermediate the ends thereof is one end of a pipe 78 that has its opposite end connected to the passageway 55 in the body 52 of the strut cylinder device 10.

The sectionalized casing of the triple diaphragm differential type self-lapping relay valve device 69 comprises three casing sections including the two above-mentioned casing sections 73 and 77 and a third casing section 79 disposed between the casing sections 73 and 77 and secured to each of these casing sections by any suitable means (not shown). This relay valve device 69 also comprises three movable abutments or diaphragms 80, 81 and 82; the effective area of the diaphragms 80 and 82 being the same and greater than the effective area of the diaphragm 81.

The outer periphery of the diaphragm 80 is clamped between the casing sections 73 and 79 and cooperates with these casing sections and the diaphragm 81 to form within the relay valve device 69 and on opposite sides of the diaphragm 80 a first pair of chambers 83 and 84, the latter being open to atmosphere via a short passageway 85 formed in the casing section 79.

The casing section 73 of the above-mentioned sectionalized casing of the relay valve device 69 is provided with a bore 86 that at its upper end opens into a coaxial counterbore 87 that in turn opens into the hereinbefore-mentioned chamber 71. The opposite or lower end of the bore 86 opens into a second coaxial counterbore 88 that in turn opens into the chamber 83. The casing section 73 is provided intermediate the ends of the bore 86 with an annular chamber 89 which is open to atmosphere via a passageway 90 formed in the casing section 73 and a choke 91 disposed in this passageway it being understood that the size of this choke 91 is such as to provide for the same rate of release to fluid under pressure from the pressure chamber of the brake cylinder device 9 as is obtained in standard AB freight car brake equipment.

Slidably mounted in the bore 86 is a valve stem 92 having intermediate its ends a collar 93 below which is a screw-threaded portion of reduced diameter which extends through the diaphragm 80 and receives in screw-threaded engagement therewith a combined diaphragm follower plate and nut 94 whereby the diaphragm 80 is operatively connected to the valve stem 92.

The wall of the bore 86 in the casing section 73 is provided with two identical spaced-apart peripheral annular grooves in each of which is disposed an O-ring 95 in sealing surrounding relation to the valve stem 92 to prevent leakage of fluid under pressure between the periphery of the valve stem and the wall of the bore 86, and from the chamber 83 and counterbore 87 to the atmospheric chamber 89.

The valve stem 92 is provided above the collar 93 thereon with a crossbore which, as shown in FIG. 4 illustrating the relative positions of the parts of the triple diaphragm self-lapping relay valve device 69 in the release position, is so located that the interior of the counterbore 87 may be open to atmosphere via a passageway 96 extending from the upper end of the valve stem 92 longitudinally therethrough to below the location thereon of the crossbore and thence via the crossbore, the chamber 89, passageway 90 and choke 91.

A flat disc valve 97 is disposed in the chamber 71 to control communication between the chamber 71 and the interior of the counterbore 87 at the wall surface of which opens one end of a passageway 98 that extends through the casing section 73 and is connected by a pipe bearing the same numeral to the brake cylinder device 9.

A spring 99, interposed between the valve 97 and the cover member 72, urges the valve 97 downward toward an annular valve seat 100 formed at the upper end of the counterbore 87.

The above-mentioned passageway 98 has a branch passageway 98*a* opening into the chamber 83 via a choke 101 which controls the rate of flow of fluid under pressure to and from the chamber 83.

The outer periphery of the smaller diagram 81 is clamped between the casing sections 79 and 77 which cooperate with this diaphragm 81 and the diaphragms 80 and 82 to form on one side of the diaphragm 81 the hereinbefore-mentioned atmospheric chamber 84 and on the opposite side a chamber 102 which is connected by a passageway and corresponding pipe 103 to the hereinbefore-mentioned displacement volume reservoir 70 that opposite side a chamber 102 which is connected by a passageway and corresponding pipe 103 to the hereinbefore-mentioned displacement volume reservoir 70 that in turn is connected by a pipe 104 to the passageway 56 in the body 52 of the strut cylinder device 10. The inner periphery of the smaller diaphragm 81 is clamped between a diaphragm follower 105 and a nut 106 that has screw-threaded engagement with a screw-threaded stem 107 integral with the follower 105 and extending from the lower side thereof through the diaphragm 81. The upper side of the diaphragm follower 105 is provided with a non-screw-threaded stem 108 that is coaxial with the hereinbefore-mentioned valve stem 92 and is normally biased against the combined diaphragm follower plate and nut 94 in a manner hereinafter made apparent.

The diaphragm 82 has its outer periphery clamped between the casing section 77 and the bottom cover member 76 and its inner periphery clamped between a diaphragm follower 109 and a combined spring seat and nut 110 that has screw-threaded engagement with a screw-threaded stem 111 integral with the follower 109 and extending from the lower side thereof through the diaphragm 82.

Disposed in the chamber 75 and interposed between the combined spring seat and nut 110 and the bottom cover member 76 is an inshot spring 112 which is effective to normally bias the diaphragms 80, 81 and 82, the valve stem 92 and the valve 97 to the position in which they are

shown in FIG. 4 of the drawings in which position the collar 93 abuts the upper end of the counterbore 88 and the valve 97 is unseated from the supply valve seat 100 and seated on an annular exhaust valve seat 113 formed at the upper end of the valve stem 92 and in surrounding relation to the upper end of the passageway 96 in the stem 92 to close communication between the pressure chamber in the brake cylinder device 9 and atmosphere. The force of the spring 112 is exerted in an upward direction on the diaphragm stack comprising the diaphragms 80, 81 and 82. The strength of the spring 112 is such that the upward force exerted thereby, together with the fluid pressure force acting in an upward direction on the smaller diaphragm 81 as the result of the supply of fluid under pressure to the chambers 75 and 102, in response to a minimum reduction of pressure in the brake pipe 2 effected while the vehicle is empty, requires a pressure of such as, for example ten pounds per square inch, in the pressure chamber of the brake cylinder device 9 and the chamber 83 above the diaphragm 80 in order to move the diaphragm stack and the valve stem 92 downward far enough for the spring 99 to effect seating of the valve 97 on the supply valve seat 100 and thereby cut off further supply of fluid under pressure from the brake cylinder pipe 17 to the pressure chamber of the brake cylinder device 9 and the chamber 83. In other words, whenever a minimum brake pipe reduction is made while the vehicle is empty, a pressure of at least, for example, ten pounds per square inch, will be obtained in the pressure chamber of the brake cylinder device 9 and the chamber 83 above the diaphragm 80.

OPERATION, FIGS. 3 AND 4

Initial charging

Fluid under pressure supplied to the brake pipe 2 shown in FIG. 3 in the manner described in connection with the previous embodiment of the invention effects charging of the brake equipment shown in FIG. 3 in the same manner as hereinbefore described for the brake equipment shown in FIG. 1 except the supply reservoir 5 shown in FIG. 1 is omited in the equipment shown in FIG. 3.

At this time, the chamber 102 in the relay valve device 69 is connected to the displacement volume reservoir 70 by the passageway and corresponding pipe 103, and this reservoir is open to atmosphere via pipe 104, passageway 56, that portion of the bottom bore 53 in the body 52 of strut cylinder device 10 below the piston 57 and port 66 in cover member 54.

Also, the chamber 75 in the relay valve device 69 is open to atmosphere via pipe and passageway 74, the brake cylinder pipe 17 and the service portion 16 of the brake control valve device 1 since the service slide valve of the service portion 16 is now in its release position in which it opens the brake cylinder pipe 17 to atmosphere.

Furthermore, the chamber 84 in the relay valve device 69 is constantly open to atmosphere via the passageway 85.

With the chambers 84, 102 and 75 in the relay valve device 69 all open to atmosphere, the spring 112 is effective to deflect the diaphragms 80, 81 and 82 to the position shown in FIG. 4 and thereby move the valve stem 92 and valve 97 to the position shown in FIG. 4 in which position the valve 97 is unseated from the supply valve seat 100 and is seated on the exhaust valve seat 113.

While the valve 97 is unseated from the supply valve seat 100, the pressure chamber in the brake cylinder device 9 is open to atmosphere via the pipe and corresponding passageway 98 counter bore 87, chamber 71, passageway and corresponding pipe 17 and the service portion 16 of the brake control valve device 1. Since the chamber 83 above the diaphragm 80 is connected to the passageway 98 via the choke 101 and branch passageway 98*a*, this chamber 83 is likewise open to atmosphere.

Service application of the brakes on an empty vehicle

A service application of the brakes can be effected by reducing the pressure in the brake pipe 2 to cause the brake control valve device 1 to effect the supply of fluid under pressure to the brake cylinder pipe 17 in the manner hereinbefore described. Fluid under pressure supplied to the brake cylinder pipe 17 will flow to the pressure chamber in the brake cylinder device 9 via passageway 17, chamber 71, past now open valve 97, counterbore 87 and passageway and corresponding pipe 98. Some of the fluid under pressure thus supplied to the passageway 98 flows therefrom to the chamber 83 above the diaphragm 80 via the branch passageway 98*a* and the choke 101.

Some of the fluid under pressure supplied to the brake cylinder pipe 17 by operation of the brake control valve device 1 will flow to the chamber 75 below the diaphragm 82 of the relay valve device 69 via the pipe and passageway 74. Some of the fluid under pressure supplied to the pipe 74 will flow therefrom to the upper face of the strut piston 57 (FIG. 4) via the pipe 78 and passageway 55.

Assuming that the vehicle is empty, the truck springs 67 and 68 (FIG. 3) are not appreciably deflected. Consequently the stop 12 and strut cylinder device 10 will occupy the relative positions in which they are shown in full lines in FIG. 4. Therefore, the fluid under pressure supplied to the upper face of the strut piston 57 of the strut cylinder device 10 will move this piston 57 and the piston rod 58 downward against the yielding resistance of the spring 60 until the lower end of the piston rod 58 contacts the upper side of the stop 12. In this position of the piston 57 the O-ring 61 carried thereby forms a seal with the wall surface of the bottom bore 53 below the location at which the passageway 56 opens at this wall surface. Consequently, the fluid under pressure supplied to the upper face of the piston 57 flows to the displacement volume reservoir 70 via the passageway 56 and pipe 104 and from the reservoir 70 to the chamber 102 between the diaphragms 81 and 82 of the relay valve device 69 via the pipe and corresponding passageway 103.

The simultaneous supply of fluid under pressure to the chambers 102 and 75 acts on the opposite sides of the effective area of the diaphragm 82 to balance the opposing fluid pressure forces acting on this diaphragm and thereby renders it ineffective.

The fluid under pressure supplied to the chamber 102 acts in an upward direction on the entire effective area of the smaller diaphragm 81. Therefore, this fluid pressure force, together with the force of spring 112, is effective to bias the diaphragm stack comprising the diaphragms 80, 81 and 82 and the valve stem 92 to the position shown in FIG. 4 in which the collar 93 on the stem 92 abuts the upper end of the counterbore 88.

In view of the above, it is apparent that the fluid under pressure supplied to the pressure chamber of the brake cylinder device 9 and the chamber 83 above the larger diaphragm 80 by operation of the brake control valve devise 1 must increase the pressure in these chambers until the pressure in the chamber 83 and acting over the effective area of the larger diaphragm 80 establishes a fluid pressure force acting in a downward direction that substantially balances the combined fluid pressure force acting on the diaphragm 81 and the force of the spring 112, which forces act in an upward direction, at which time the spring 99 will be rendered effective to move the diaphragm stack and the valve stem 92 downward to seat the valve 97 on the supply valve seat 100 to cut off flow of fluid under pressure from the brake cylinder pipe 17 to the pressure chamber in the brake cylinder device 9 and the chamber 83 above the larger diaphragm 80. From the foregoing, it is apparent that the pressure supplied to the pressure chamber of the brake cylinder device 9 and to the chamber 83 is less than the pressure supplied to the chambers 75 and 102 in inverse ratio to the areas of the diaphragms 80 and 81 and also the strength of the

spring 112. It will be understood, however, that this pressure in the pressure chamber of the brake cylinder device 9 always provides an adequate braking force for an empty vehicle even when a minimum brake pipe reduction is effected in the brake pipe 2. In other words, the spring 112 insures that at least a chosen pressure, such as for example, ten pounds per square inch, is always obtained in the pressure chamber of the brake cylinder device 9 when a minimum brake pipe reduction is effected.

Release of a service application on an empty vehicle

When it is desired to effect a release of a service brake application, the pressure in the brake pipe 2 will be increased in the usual manner whereupon the service portion 16 of the brake control valve device 1 will operate in the manner hereinbefore described to establish a communication between the brake cylinder pipe 17 and atmosphere.

Since the brake cylinder pipe 17 is now open to atmosphere and this pipe is connected to the chamber 75 in the relay valve device 69 via the pipe and corresponding passageway 74, fluid under pressure will be vented from the chamber 75 to atmosphere. Fluid under pressure will also be vented from the chamber 102 in the relay valve device 69 via the passageway and corresponding pipe 103, displacement volume reservoir 70, pipe 104, passageway 56, bottom bore 53, passageway 55, pipes 78, 74 and 17, and the brake control valve device 1.

As fluid under pressure is simultaneously vented from the chambers 102 and 75, as just described, the fluid under pressure in the chamber 83 is rendered effective to deflect the diaphragm stack comprising diaphragms 80, 81 and 82 downward and thereby move the valve stem 92 downward so that the exhaust valve seat 113 on the upper end thereof is moved away from the lower side of the valve 97 which is biased against the supply valve seat 100 at this time by the spring 99. When the exhaust valve seat 113 is thus moved away from the lower side of the valve 97, fluid under pressure will be vented from the pressure chamber in the brake cylinder device 9 to atmosphere via pipe and passageway 98, counterbore 87, passageway 96 and the crossbore in the valve stem 92, chamber 89, passageway 90 and choke 91 at a rate controlled by the size of this choke 91, the size of which, as hereinbefore stated, provides for the release of fluid under pressure from the brake cylinder device 9 at the same rate as is obtained in the standard single capacity brake equipment that includes the well-known AB brake control valve device.

Since the chamber 83 is connected to the passageway 98 via the branch pipe 98*a* and choke 101, fluid under pressure will be vented from the chamber 83 to atmosphere simultaneously as fluid under pressure is vented from the brake cylinder device 9 to atmosphere.

Fluid under pressure will be vented from the chambers 75, 102 and 83 in the relay valve device 69 to atmosphere in the manner explained above until the fluid pressure force acting downward on the diaphragm stack comprising the diaphragms 80, 81 and 82 is reduced to a value substantially equal to the force of the spring 112 acting in an upward direction on this diaphragm stack. As the downwardly acting fluid pressure force acting on the diaphragm stack is reduced to a value less than the force of the spring 112 acting upward on this stack due to the continued reduction of pressure in the chambers 83, 102 and 75 as the result of venting fluid under pressure therefrom to atmosphere, the spring 112 is rendered effective to move the diaphragm stack and the stem 92 upward until first the exhaust valve seat 113 is moved into contact with the lower side of the valve 97 to cut off further venting of fluid under pressure from the brake cylinder device 9 and chamber 83 to atmosphere via the choke 91.

As the pressure in the chambers 75 and 102 is further reduced by flow therefrom to atmosphere, the spring 112 will continue to deflect the diaphragm stack upward to move the valve stem 92 upward and thereby unseat valve 97 from the supply valve seat 100. When the valve 97 is thus unseated, the remaining fluid under pressure in the brake cylinder device 9 and the chamber 83 flows to atmosphere past the unseated valve 97, and thence via the chamber 71, passageway and corresponding pipe 17 and the service portion 16 of the brake control valve device 1 thereby completely releasing the brakes on the vehicle.

As fluid under pressure is vented from the chamber 75 in the relay valve device 89, it is likewise vented from the top face of the strut piston 57 whereupon the spring 60 is rendered effective to move the piston 57 and piston rod 58 upward so that the lower end of the piston rod 58 is moved upward out of contact with the stop 12. When the piston 57 is thus moved upward to a position in which the O-ring 61 carried thereby forms a seal with the wall surface of the bottom bore 53 just above the location at which the passageway 56 opens at this wall surface, the remaining fluid under pressure present in the chamber 102 and displacement volume reservoir 70 connected thereto by the pipe and corresponding passageway 103, will be vented to atmosphere via pipe 104, passageway 56, that portion of the bottom bore 53 below the piston 57 and the port 66 in the cover member 54. The fluid under pressure remaining in that portion of the bottom bore 53 above the piston 57 is now vented to atmosphere via passageway 55, pipes 78, 74 and 17, and the service portion 16 of the brake control valve device 1. Likewise, the fluid under pressure remaining in the chamber 75 is vented to atmosphere via pipes 74 and 17 and the service portion 16 of the brake control valve device 1.

Service application of the brakes on a loaded vehicle

Let it be supposed that the brake equipment shown in FIG. 3 has been charged in the manner hereinbefore described and that the vehicle is fully loaded.

The load transmitted in the manner hereinbefore described to the bolster 11 is effective to compress the springs 67 and 68 shown in FIG. 3 so that the bolster 11 and the strut cylinder device 10 carried thereby together with the other devices constituting the brake equipment shown in FIG. 3 are moved downward toward the stop 12 until strut cylinder device 10 occupies the position relative to the stop 12 indicated by broken lines in FIG. 4. Consequently, the distance between the bottom of the piston rod 58 and the top side of the stop 12 will be such, due to the compression of the truck springs 67 and 68, that when a service brake application is effected in the manner hereinbefore described to cause the strut piston 57 to move downward, as viewed in FIG. 4, until the lower end of piston rod 58 strikes the top side of the stop 12, this piston will not be moved to the position in which the O-ring 61 carried thereby makes a seal with the wall surface of the bottom bore 53 below the opening of the passageway 56 at this wall surface. Therefore, the fluid under pressure supplied to the top face of the strut piston 57 cannot flow to the displacement volume reservoir 70 via the passageway 56 and pipe 104 and thence from the reservoir 70 to the chamber 102 in the relay valve device 69 via the pipe and corresponding passageway 103.

When a service brake application is effected in the manner hereinbefore described, the brake control valve device 1 operates to effect the supply of fluid under pressure from the auxiliary reservoir 3 to the brake cylinder pipe 17 from whence it flows to the pressure chamber in the brake cylinder device 9 via the passageway 17, chamber 71, past the unseated valve 97, counterbore 87 and passageway and corresponding pipe 98. Some of the fluid under pressure thus supplied by the brake control valve device 1 to the brake cylinder pipe 17 flows therefrom to the chamber 75 in the relay valve device 69 and to the upper face of the strut piston 57.

Fluid under pressure supplied to the upper face of the

strut piston **57** in the manner just described is effective to move this piston and the piston rod **58** downward against the yielding resistance of the spring **60**.

The strut piston **57** and piston rod **58** will thus be moved downward until the lower end of the piston rod is moved into contact with the stop **12** carried by the truck side frames **13** and **14**.

When the piston **57** is moved downward to the position in which the lower end of the piston rod **58** is in contact with the stop **12** while the strut cylinder device **10** occupies the position relative to the stop **12** indicated by broken lines in FIG. 4, the O-ring **61** carried by the piston **57** is in a position in which it makes a seal with the wall surface of the bottom bore **53** above the location at which the passageway **56** opens at this wall surface. Therefore, the fluid under pressure supplied from the brake cylinder pipe **17** to the upper face of the piston **57** via pipes **74** and **78**, the passageway **55** and the bottom bore **53** cannot flow to the chamber **102** above the diaphragm **82** in the relay valve device **69** via the passageway **56**, pipe **104**, displacement volume reservoir **70** and pipe and corresponding passageway **103**. Consequently, the chamber **102** remains open to atmosphere via passageway and corresponding pipe **103**, reservoir **70**, pipe **104**, passageway **56**, that portion of bottom bore **53** that is below the strut piston **57** and port **66** in cover member **54**.

The effective area of the diaphragms **80** and **82** is the same and the lower side of the diaphragm **82** is subject to the force of the spring **112** and the fluid under pressure supplied to the chamber **75** from the brake cylinder pipe **17**. The upper side of the diaphragm **80** is subject only to the fluid under pressure supplied to the chamber **83** from the brake cylinder pipe **17**. The spring **112**, therefore, is effective to maintain the diaphragm stack and the valve stem **92** in the position shown in FIG. 4 in which the valve **97** is unseated from the supply valve seat **100** and seated on the exhaust valve seat **113**. Accordingly, fluid under pressure will flow from the auxiliary reservoir **3** to the pressure chamber in the brake cylinder device **9**, and to the chambers **75** and **83** in the relay valve device **69** until the pressure in the auxiliary reservoir **3** and acting on one side of the service piston (not shown) of the service portion **16** of the brake control valve device **1** is reduced slightly below the brake pipe pressure acting on the opposite side of this service piston at which time this service piston will move the service slide valve of the service portion **16** to its lap position to cut off further flow of fluid under pressure from the auxiliary reservoir **3** to the pressure chamber in the brake cylinder device **9** and the chambers **75** and **83** in the relay valve device **69**.

From the foregoing it is apparent that the same pressure is supplied to the pressure chamber in the brake cylinder device **9** as is supplied to the brake cylinder pipe **17** and chambers **75** and **83** in the relay valve device **69** by the brake control valve device **1**. It will be understood that this pressure is greater than the pressure supplied to the pressure chamber of the brake cylinder device **9** when the vehicle is empty and therefore, provides for a greater braking force on the loaded vehicle than is provided for an empty vehicle.

Release of a service application of brakes on a loaded vehicle

To release a service brake application on a loaded vehicle, the pressure in the brake pipe **2** is increased to its normal charged value to cause the service portion **16** of the brake control valve device **1** to operate to establish a communication between the brake cylinder pipe **17** and atmosphere as in the first embodiment of the invention.

The pressure chamber in the brake cylinder device **9** is connected to the brake cylinder pipe **17** via the pipe and corresponding passageway **98**, counterbore **87**, chamber **71** and passageway **17**; the chamber **83** in the relay valve device **69** is connected to the passageway **98** via the choke **101** and branch passageway **98***a*; the chamber **75** in the relay valve device **69** is connected to the brake cylinder pipe **17** via the passageway and corresponding pipe **74**; and that portion of the bottom bore **53** in the body **52** of strut cylinder device **10** above the strut piston **57** is connected to the pipe **74** via the passageway **55** and pipe **78**. Consequently, fluid under pressure will now be vented from the pressure chamber in the brake cylinder device **9**, the chambers **83** and **75** in the relay valve device **69** and the upper portion of the bottom bore **53** above the piston **57** to atmosphere. This venting of fluid under pressure from the pressure chamber of the brake cylinder device **9** causes a release of the brake on the loaded vehicle.

As in the first embodiment of the invention, when an emergency brake application is effected, fluid under pressure from both the auxiliary reservoir **3** and emergency reservoir **4** is supplied to the brake cylinder pipe **17** and thence to the pressure chamber of the brake cylinder device **9** to give a higher equalization pressure and therefore, a higher braking force than is obtained when a service brake application is effected. A release of an emergency brake application is effected in the same manner as a release of a service brake application.

Having now described the invention, what we claim as new and desire to secure by Letters Patent, is:

1. In an empty and load fluid pressure brake equipment for a vehicle having a sprung part and an unsprung part, the combination of:

(a) a brake pipe normally charged with fluid under pressure,

(b) a reservoir normally charged to the pressure in said brake pipe,

(c) fluid pressure operated braking means for effecting a brake application,

(d) a fluid pressure operated relay valve means having a plurality of operating pressure chambers, said relay valve means being operable to establish one degree of fluid pressure in said fluid pressure operated braking means in response to the supply of fluid under pressure to only one of said pressure chambers and operable to establish a different degree of fluid pressure in said fluid pressure operated braking means in response to the supply of fluid under pressure concurrently to said one chamber and to another of said chambers,

(e) stop means carried by one of said sprung and unsprung parts of the vehicle,

(f) fluid pressure operated load measuring means carried by the other of said sprung and unsprung parts of the vehicle and comprising:

(i) piston valve means, and

(ii) a valve stem operably connected to said piston valve means and movable thereby into abutting relationship with said stop means when said piston valve means is subject to fluid under pressure, said piston valve means selectively causing the supply of fluid under pressure acting on said piston valve means to said another chamber of said relay valve means depending upon the relative position of said stem to said stop means as determined by the degree of load carried by the vehicle, and

(g) a fluid pressure responsive brake control valve device operative upon a reduction in the pressure in said brake pipe to effect the supply of fluid under pressure from said reservoir to said one chamber of said relay valve means and to said another chamber of the relay valve means subject to control by the piston valve means, whereby said relay valve means operates selectively to establish different degrees of fluid pressure in the braking means dependent on the load carried by the vehicle.

2. In an empty and load fluid pressure brake equipment for a vehicle having a sprung part and an unsprung part, the combination disclosed in claim **1** wherein the stop

means is carried on the unsprung part of the vehicle and the fluid pressure operated load measuring means is carried on the sprung part of the vehicle.

3. In an empty and load fluid pressure brake equipment for a vehicle having a sprung part and an unsprung part, the combination disclosed in claim 1 wherein the fluid pressure operated relay valve means is characterized by a pair of spaced-apart movable abutments of unequal effective area, and in that said one of said plurality of operating pressure chambers is disposed at one side of one of said abutments, and the said another of said plurality of pressure chambers is disposed between said pair of movable abutments.

4. In an empty and load fluid pressure brake equipment for a vehicle having a sprung part and an unsprung part, the combination disclosed in claim 1 wherein the fluid pressure operated relay valve means is characterized by three coaxially arranged spaced-apart movable abutments, the outer two abutments each having the same effective area which exceeds the effective area of the intermediate third one of said movable abutments, and in that said one

of said plurality of operating pressure chambers is disposed at one side of one of said two outer abutments, and the said another of said pressure chambers is between said one of said two outer abutments and said intermediate third one of said abutments.

5. In an empty and load fluid pressure brake equipment for a vehicle having a sprung part and an unsprung part, the combination disclosed in claim 4 wherein the fluid pressure operated relay means is characterized by a resilient means disposed at said one side of said one of said two outer abutments to exert a chosen force thereon in the same direction as fluid under pressure supplied to said one of said plurality of operating pressure chambers.

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